

1 TITLE

2 Exhaust gas after treatment system, especially for a diesel
3 engine

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6 CROSS REFERENCE APPLICATIONS

7 This application is a national stage application
8 claiming priority from PCT application no. PCT/EP03/109171
9 filed on October 2, 2003 and claiming priority from German
10 application 102 50 050.96 filed on October 25, 2002.

11

12 FIELD OF INVENTION

13 The invention relates to an exhaust gas after treatment
14 system, especially for a diesel engine, having the features
15 of the preamble of claim 1.

16

17 BACKGROUND OF THE INVENTION

18 German laid-open specification DE 100 42 542 A1 has
19 described an exhaust gas after treatment system having an
20 exhaust gas particulate filter and an SCR catalytic
21 converter. The exhaust gas particulate filter and the SCR
22 catalytic converter are arranged in the housing of the
23 exhaust gas after treatment system and form a structural
24 unit therewith. Urea is used as a reducing agent for the
25 selective catalytic reduction of nitrogen oxides and is

1 injected into a special tube element. The special tube
2 element is arranged in the housing parallel to the exhaust
3 gas particulate filter and has filtered exhaust gas flowing
4 through it, with the urea then being fed to the SCR
5 catalytic converter. In the housing there is a plurality of
6 chambers which are separated from one another by partitions
7 and act as reflection chambers and/or absorption chambers,
8 thereby producing a muffling action.

9 It is an object of the invention to provide an exhaust
10 gas after treatment system which can achieve comprehensive
11 exhaust gas purification, which is of structurally simple
12 and compact configuration and can be used for optimum sound
13 muffling.

14 According to the invention, this object is achieved by
15 an exhaust gas after treatment system having the features of
16 claim 1.

17 SUMMARY OF THE INVENTION

18 According to the invention, the exhaust gas particulate
19 filter is formed as a porous cylindrical filter body having
20 a substantially radial exhaust gas inflow direction into the
21 filter body, a filter inner region for filtered exhaust gas,
22 and an axial exhaust gas outflow direction out of the filter
23 inner region, and there is provision for reducing agent to
24 be added into the filter inner region by means of the
25 apparatus for adding reducing agent.

1 The filter body is designed as a cylindrical hollow
2 body with a porous cylinder wall and is preferably
3 configured in such a way that filtered exhaust gas can flow
4 out of the filter inner region in the axial direction on one
5 side. The filter inner region in this context is to be
6 understood as meaning the volume region which can be filled
7 with filtered exhaust gas upstream of the outflow side
8 filter body end. The wall material of the filter body can
9 act as a depth filter or as a surface filter and may be
10 formed from any desired porous material which has a
11 filtering action and is able to withstand exhaust gases, for
12 example metal foam or ceramic foam. Moreover, it may
13 additionally be provided with a catalytic coating on the
14 outer side, the inner side or in the porous interior of the
15 material.

16 A suitable nitrogen oxide reduction catalytic converter
17 is any catalytic converter which is able to catalyze the
18 reduction of nitrogen oxides by a suitable reducing agent.
19 The reducing agent used may be any reagent which has a
20 nitrogen oxide reduction activity. The nitrogen oxide
21 reduction catalytic converter is preferably designed as a
22 standard SCR catalytic converter based on vanadium
23 pentoxide, and therefore the reducing agent is ammonia or a
24 liquid from which ammonia can be released. It is preferable
25 for the reducing agent used to be aqueous urea solution.

1 Accordingly, the apparatus for adding reducing agent is
2 preferably designed as an injection nozzle.

3 The particulate filter and the downstream nitrogen
4 oxide reduction catalytic converter may be arranged in
5 separate housings or in a common housing.

6 The addition of reducing agent into the inner region of
7 the filter body results in a space saving design solution
8 with short gas paths. This prevents cooling of the exhaust
9 gas before the reducing agent is added, resulting in
10 favorable thermal conditions for preparation of the reducing
11 agent, for example for release of the ammonia or for
12 evaporation. Moreover, the addition of reducing agent into
13 the filter inner region achieves a good uniform distribution
14 and homogenization of the reducing agent in the exhaust gas.

15 In one configuration of the invention, the filter body
16 is formed by porous filter plate rings which are combined in
17 pairs. It is preferable for the filter body to be formed
18 from flat, annular sintered-metal filter plates which are
19 fixedly joined to one another, for example by a weld seam,
20 alternately and in pairs along their outer circumference and
21 along their inner ring circumference. It is preferable for
22 the filter body to have a sealed end plate at one end, while
23 an annular, gastight end plate is arranged at the other end;
24 the filtered exhaust gas can flow out of the opening in the
25 annular end plate in the axial direction. The filter plate

1 rings may be of any desired shape, but it is preferable for
2 them to be approximately round with a central hole in the
3 middle. This produces a cylindrical filter body with a shape
4 similar to an accordion with contours that are approximately
5 in zigzag form when seen in longitudinal section. This is
6 distinguished by a large filter surface area and a low
7 pressure loss, as well as a high muffling action. This makes
8 it possible to substantially dispense with any further
9 structural muffling measures in the exhaust gas
10 aftertreatment system.

11 In a further configuration of the invention, the
12 nitrogen oxide reduction catalytic converter and the
13 particulate filter are arranged in a common housing. This
14 avoids the need for multiple exhaust gas connections and
15 produces a compact structure of the exhaust gas
16 aftertreatment system. In particular in the case of an
17 exhaust gas particulate filter constructed from
18 sintered-metal filter rings, an exhaust gas muffler with an
19 exhaust gas purification function is realized by this
20 structure on account of its muffling action.

21 In a further configuration of the invention, there are
22 flow guiding means for passing on filtered exhaust gas to
23 the nitrogen oxide reduction catalytic converter, which flow
24 guiding means comprise a collection manifold led out of the
25 filter inner region of the filter body. If the filter body

1 is constructed from sintered-metal filter rings, the
2 collection manifold, in addition to collecting and passing
3 on exhaust gas, also serves to increase mechanical
4 stability. The individual filter plate rings can be
5 supported on the collection manifold. In the filter inner
6 region, the collection manifold preferably has a perforated
7 wall for the exhaust gas entry. If the nitrogen oxide
8 reduction catalytic converter and the particulate filter are
9 arranged in a common housing, it is furthermore possible for
10 one or more partition walls to be arranged suitably in the
11 housing, by which partitions the housing is divided into
12 chambers. In this case, the partition or partitions likewise
13 serve as flow guiding means for passing on filtered exhaust
14 gas to the nitrogen oxide reduction catalytic converter or
15 serve to route the exhaust gas flow in some other way in the
16 interior of the housing and at the same time prevent
17 back-mixing.

18 In a further configuration of the invention, a
19 catalytic converter element is arranged in the collection
20 manifold. A catalytic converter element of this type, as
21 seen in the direction of flow of the exhaust gas, may be
22 arranged both in the filter inner region preferably just
23 downstream of the location where the reducing agent is
24 added, or further downstream. In the case of the urea being
25 used as the reducing agent, it is preferably designed as a

1 hydrolysis catalytic converter which promotes the release of
2 ammonia. The arrangement of the catalytic converter element
3 according to the invention produces a particularly compact
4 and space-saving overall design.

5 In a further configuration of the invention, the
6 nitrogen oxide reduction catalytic converter is arranged
7 axially parallel and adjacent to the collection manifold. In
8 an arrangement of this type, the nitrogen oxide reduction
9 catalytic converter may comprise one or more catalytic
10 converter parts. If the nitrogen oxide reduction catalytic
11 converter is of multi-part design, it is preferable for the
12 individual catalytic converter parts to be arranged axially
13 parallel around the collection manifold. This embodiment
14 allows the volume of the nitrogen oxide reduction catalytic
15 converter to be increased in a space-saving way.

16 In a further configuration of the invention, an
17 oxidation catalytic converter is connected upstream of the
18 exhaust gas particulate filter, as seen in the direction of
19 flow of the exhaust gas. This can be realized by a separate
20 catalytic converter element in a separate housing or in the
21 housing in which the exhaust gas particulate filter is
22 arranged. The oxidation catalytic converter is used, for
23 example, to oxidize hydrocarbons or to oxidize nitrogen
24 monoxide to form nitrogen dioxide. The latter improves the
25 regeneration behavior of the particulate filter.

1 In a further configuration of the invention, the
2 exhaust gas particulate filter and the oxidation catalytic
3 converter are arranged in a common housing. This arrangement
4 produces a particularly compact structural unit.

5 In a further configuration of the invention, an exhaust
6 gas recirculation line which is led out of the filter inner
7 region for branching off a part-stream of filtered exhaust
8 gas upstream of the addition of reducing agent and for
9 recirculating this part-stream of filtered exhaust gas to
10 the diesel engine is provided. The result of this measure is
11 that filtered exhaust gas that is free of reducing agent in
12 the exhaust gas recirculation line is fed to the diesel
13 engine. This prevents condensation in the components which
14 come into contact with the recirculated exhaust gas.

15
16 Other aspects of this invention will appear from the
17 following description and appended claims, reference being
18 made to the accompanying drawings forming a part of this
19 specification wherein like reference characters designate
20 corresponding parts in the several views.

21

22 **BRIEF DESCRIPTION OF THE DRAWINGS**

23 Fig. 1 is a diagrammatic sectional illustration of an
24 embodiment of the exhaust gas purification system
25 according to the invention.

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2 Fig. 2 is a diagrammatic sectional illustration of a further
3 embodiment of the exhaust gas purification system
4 according to the invention.

5

6 Before explaining the disclosed embodiment of the
7 present invention in detail, it is to be understood that the
8 invention is not limited in its application to the details
9 of the particular arrangement shown, since the invention is
10 capable of other embodiments. Also, the terminology used
11 herein is for the purpose of description and not of
12 limitation.

13

14 DETAILED DESCRIPTION OF THE DRAWINGS

15 Fig. 1 diagrammatically depicts a longitudinal section
16 through an embodiment of the exhaust gas purification system
17 according to the invention. In the present case, this system
18 comprises a particulate filter 3 and an SCR catalytic
19 converter comprising two honeycomb monoliths 7, 8, which are
20 arranged in a common housing 2 having an entry tube 1 and an
21 outflow tube 9. A collection manifold 6 and partitions 18,
22 19, 20, 21 are provided in the housing 2 for the purpose of
23 routing the exhaust gas. The way in which the exhaust gas
24 purification system functions is explained below with

1 reference to the description of the exhaust gas flow path,
2 which is diagrammatically indicated by arrows.

3 Exhaust gas from a diesel engine (not shown) flows
4 through the entry tube 1 into an inflow chamber 10 of the
5 housing 2. The partition 18 separates the inflow chamber 10
6 from a particulate filter chamber 11, in which the
7 particulate filter 3 is arranged. Along its circumference,
8 the partition 18 is joined to the housing 2, but it has
9 apertures in the form of holes, preferably arranged in a
10 ring along its edge region. These apertures allow the
11 exhaust gas which has flowed into the inflow chamber 10 to
12 pass into the particulate filter chamber 11. The partition
13 19 delimits the other end side of the particulate filter
14 chamber 11 and prevents unfiltered exhaust gas from being
15 transferred onward into the part of the housing located
16 further downstream

17 The particulate filter 3 is constructed from individual
18 filter rings, of which just one filter ring 4 is provided,
19 as a representative example, with a reference numeral. The
20 individual filter rings are designed as sintered-metal
21 filter plates with a central hole and are fixedly joined to
22 one another, for example by a weld seam, on alternate sides
23 and in pairs along their outer circumference and along their
24 inner ring circumference. This forms a filter body which is
25 accordion-like in form with outer and inner filter pockets.

1 The end-side filter rings of the filter body are joined in a
2 gastight manner to the respective partitions 18, 19 all the
3 way around. The exhaust gas which has entered the
4 particulate filter chamber 11 therefore flows onward through
5 the filter rings of the filter body into the filter inner
6 region 26, with particulates contained in the exhaust gas
7 being filtered out in the process. The main direction of
8 flow of the exhaust gas therefore runs radially from the
9 outer region of the filter body into its inner region 26.

10 In the filter inner region 26, the filtered exhaust gas
11 is received by a collection manifold 6, which is designed
12 with perforations on its lateral surface in the interior of
13 the filter body. The collection manifold 6 preferably has
14 the same cross section as the holes in the sintered-metal
15 filter plates over the majority of its length; consequently,
16 the sintered-metal filter plates are supported against the
17 collection manifold 6 in the form of a ring all the way
18 around it in the interior of the filter body, resulting in a
19 high mechanical stability of the filter body.

20 At encircling gastight connections, the collection
21 manifold 6 is routed out of the particulate filter chamber
22 11, on one side through partition 18 and on the other side
23 through partitions 19, 20, 21, into the inflow chamber 10
24 and into a first diversion chamber 14, respectively. In the
25 region of the inflow chamber 10, an apparatus for adding

1 reducing agent is connected in a gastight manner to the
2 collection manifold 6. This apparatus is only
3 diagrammatically indicated in Fig. 1, as a feed line 17 for
4 a urea and water solution, which is routed into the
5 collection manifold 6, which narrows at the corresponding
6 end. Urea and water solution as reducing agent can be
7 injected into the filter inner region 26 through the feed
8 line 17, in a manner which is targeted and in accordance
9 with demand but is not indicated in more detail here. It is
10 preferable for the injection of the urea and water solution
11 to be assisted by compressed air. In the end region of the
12 feed line 17, the collection manifold 6 widens out in the
13 direction of flow, resulting in a good uniform distribution
14 of the reducing agent supplied in the filter inner region
15 26. To further improve the distribution of reducing agent,
16 for example by swirling it up, the collection manifold 6 may
17 be provided, in the conically narrowing end region, with
18 holes (not shown) which allow a small quantity of unfiltered
19 exhaust gas from the inflow chamber 10 to enter the
20 collection manifold 6. This results in further improved
21 mixing of the reducing agent which is added with filtered
22 exhaust gas in the upstream region of the collection
23 manifold 6.

24 To prepare the reducing agent which has been added
25 and/or to improve the release of ammonia from the urea which

1 is added, it is possible for a suitable catalytic converter
2 to be arranged in the collection manifold 6. This catalytic
3 converter is in this case embodied by the catalytic
4 converter disks 15 and 16, which act as hydrolysis catalysts
5 prompting the decomposition of urea and the release of
6 ammonia. The hydrolysis catalyst may in principle be
7 arranged at any desired location in the collection manifold
8 6 downstream of the addition of urea, but it is preferable
9 for a first catalytic converter part 15 to be arranged just
10 downstream of the addition of the urea and for a second
11 catalytic converter part 16 to be arranged in the end region
12 of the collection manifold 6. The hydrolysis catalyst may in
13 this case be designed such that it can be electrically
14 heated completely or in parts, in order to further improve
15 the decomposition of urea.

16 The exhaust gas which has been mixed with the reducing
17 agent is passed through the collection manifold 6 until it
18 reaches a first diversion chamber 14, where it emerges from
19 the end-side opening of the collection manifold 6. From
20 there, it is fed to the nitrogen oxide reduction catalytic
21 converter. The latter is in this case realized by two
22 cylindrical SCR catalytic converter monoliths 7, 8, which
23 are arranged axially parallel and adjacent to the collection
24 manifold 6. However, it is, of course, also possible to
25 arrange further catalytic converter parts fitted around the

1 collection manifold 6. At their entry side end the SCR
2 catalytic converters 7, 8 are passed through corresponding
3 openings in the partition 21, in a manner which is sealed
4 all around. The partition 21 is joined to the housing 2 in a
5 fixed and gastight manner along its circumference, and
6 therefore serves both as a flow guiding means for the
7 exhaust gas or exhaust gas/reducing agent mixture and as a
8 mechanical holder for the SCR catalytic converters 7, 8 and
9 the collection manifold 6. At their exit side end, the SCR
10 catalytic converters 7, 8 are passed through corresponding
11 openings in the partition 20, although here the SCR
12 catalytic converters 7, 8 do not necessarily have to be
13 fitted in a gastight manner into the corresponding openings
14 in the partition 20.

15 The exhaust gas, which is purified by the removal of
16 nitrogen oxides as it passes through the SCR catalytic
17 converters 7, 8 emerges from the SCR catalytic converters 7,
18 8 in a second diversion chamber, which is laterally
19 delimited by the partitions 19, 20. Since the partition 20
20 is of partially perforated design, whereas the partition 19
21 forms a gastight closure with respect to the particulate
22 filter chamber 11, the purified exhaust gas, after its
23 direction of flow has changed, is passed onward through the
24 perforated partition 20 into an outflow chamber 13.

1 In the outflow chamber 13, the exhaust gas is received
2 by an outflow tube 9, which is routed from there through the
3 partition 21 and the wall of the housing 2 and then out of
4 the housing 2, so that the exhaust gas is passed out of the
5 housing 2. The outflow tube 9 is preferably of perforated
6 design at its entry-side end region and provided with a
7 perforated end plate. This, like the perforations in the
8 partitions 18 and 20, makes a contribution to muffling.

9 The embodiment described therefore forms an exhaust gas
10 after treatment system which is of structurally simple and
11 compact configuration and can achieve comprehensive exhaust
12 gas purification and, in addition, particularly effective
13 muffling.

14 The purifying action of the exhaust gas after treatment
15 system according to the invention can be improved further by
16 adding an additional catalytic function. This may consist,
17 for example, in a catalytically active coating applied to
18 the inflow side or outflow side surface of the filter rings.
19 However, the catalytic function may also be realized by
20 sintered material filter rings in which the sintered
21 material itself has a catalytic activity. Furthermore, it is
22 possible for the catalytic function to be realized by plate
23 elements with an oxidation/catalyzing action, for example,
24 secured to the filter body. Fig. 1 illustrates a single
25 catalytic plate element 5 of annular design as a

1 representative example of possibly a plurality of catalytic
2 plate elements of this type. This catalytic plate element 5
3 extends in the radial direction into the outer region of the
4 filter body. It is preferable for the filter body to be
5 designed in accordance with what is described in German
6 laid-open specification DE 100 35 544 A1 and provided with
7 catalytically active plate elements.

8 Fig. 2 illustrates a further advantageous embodiment of
9 the exhaust gas after treatment system according to the
10 invention. In this case, the components of the arrangement
11 shown in Fig. 2, where they correspond to the parts shown in
12 Fig. 1, are denoted by the same reference numerals.

13 The exhaust gas after treatment system illustrated in
14 Fig. 2 differs from the system illustrated in Fig. 1
15 substantially by virtue of having an oxidation catalytic
16 converter, which in this case comprises two honeycomb
17 monoliths 24, 25 and which is connected upstream of the
18 particulate filter 3, as seen in the direction of flow of
19 the exhaust gas. For this purpose, an intermediate chamber
20 23 has been added to the housing 2 compared to the
21 embodiment illustrated in Fig. 1. The intermediate chamber
22 23 separates the inflow chamber 10 from the particulate
23 filter chamber 11 by means of the partition 22. The
24 partition 22 has openings for the feed line 17 to pass
25 through in a gastight manner and for receiving the catalytic

1 converter bodies 24, 25 such that they are sealed all the
2 way around, and moreover this partition 22 separates the
3 inflow chamber 10 from the intermediate chamber 23 in a
4 gastight manner. The exhaust gas which flows into the inflow
5 chamber 10 of the housing 2 via the entry tube 1 is
6 therefore passed into the intermediate chamber 23 via the
7 catalytic converter bodies 24, 25 before it is fed into the
8 particulate filter chamber 11. As a result, the exhaust gas
9 undergoes an oxidation-catalyzing treatment before it is
10 filtered, during which treatment the level of oxidizable
11 constituents, such as hydrocarbons or carbon monoxide, in
12 the exhaust gas is reduced. Furthermore, nitrogen monoxide
13 contained in the exhaust gas can be oxidized to form
14 nitrogen dioxide, thereby facilitating the burn-off of
15 carbon particulates that have been deposited on the filter
16 body. This embodiment makes it possible to dispense with the
17 plate elements with an oxidation-catalyzing action secured
18 to the filter body of the embodiment illustrated in Fig. 1.

19 Further improvement to the emission of pollutants can
20 be achieved by exhaust gas recirculation. For this purpose,
21 an exhaust gas recirculation line (not shown), which opens
22 out into the filter inner region 26 upstream of the addition
23 of reducing agent is routed out of the housing 2 and
24 connected to the intake pipe system of the engine. In this
25 way, filtered exhaust gas without any reducing agent can be

1 recirculated to the engine. The exhaust gas recirculation
2 described can of course be realized both in the embodiment
3 shown in Fig. 1 and in the embodiment shown in Fig. 2.
4